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Research article

Association of vitamin B1 intake with geriatric cognitive function: An analysis of the National Health and Nutrition Examination Survey (NHANES) from 2011 to 2014

Kangkang Ji [a,c,1], Minli Sun [b,1], Ye Hong [c], Li Li [a], Xin Wang [b], Chaonian Li [b], Shengkai Yang [d], Wenjuan Du [d], Kangjie Xu [a], Hai Zhou [a,d,*]

[a] Department of Central Laboratory, Binhai County People's Hospital, Yancheng 224000, China
[b] Department of Geriatrics, Binhai County People's Hospital, Yancheng 224000, China
[c] Department of Clinical Nutrition, Binhai County People's Hospital, Yancheng 224000, China
[d] Department of Neurocentres, Binhai County People's Hospital, Yancheng 224000, China

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ABSTRACT

Background: The association between dietary vitamin B1 intake and cognitive performance in the noninstitutionalized older adult population of the United States remains unclear.
Purpose: This study aimed to investigate the association between vitamin B1 intake and cognitive performance in older adults in the United States.
Methods: Vitamin B1 intake was assessed through two 24-h dietary recalls. Weighted logistic regression was used to evaluate the association between vitamin B1 intake and three cognitive scores (immediate recall test [IRT], animal fluency test [AFT], and digit symbol substitution test [DSST]). Cognitive performance was measured by these three tests, and individuals scoring below the lowest quartile were categorized as cognitive impairment. Sensitivity analysis, including dose–response curves, subgroup analyses, interaction effects, per 1 SD, and quartiles, were performed to ensure the accuracy of the conclusion.
Results: A total of 2896 participants over the age of 60 were included in this study. In the adjusted final model, the association between vitamin B1 intake and low cognitive performance in old age was statistically significant, with the following odds ratios (ORs) and 95% confidence intervals (CIs): IRT, 0.75 (0.57, 0.97), P = 0.018; AFT, 0.68 (0.50, 0.92), P = 0.007; DSST, 0.71 (0.54, 0.92), P = 0.005. Subgroup analyses showed that this association was statistically significant among males, white, low-education, and no memory impairment. The results of the sensitivity analyses confirmed the association between VB1 and cognitive function in old age and the absence of interactions in the final calibrated model.
Conclusion: Dietary vitamin B1 intake is negatively associated with cognitive performance in older adults.

* Corresponding author. Department of Central Laboratory, Binhai County People's Hospital, Yancheng 224000, China.
E-mail address: zhouhai3212@163.com (H. Zhou).
[1] Kangkang Ji and Minli Sun contributed equally to this work.

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1. Introduction

Global aging is a growing problem, particularly in the United States [1]. Cognitive decline is an inevitable occurrence among the older adult population, making cognitive health a significant public health concern [2]. Cognitive function encompasses various mental processes such as acquiring knowledge, attention, memory, and decision-making [3]. Cognitive decline adversely affects daily life and reduces the overall quality of life [4]. Moreover, cognitive impairments are often considered precursors to conditions like Alzheimer's disease and other forms of dementia [5,6]. The healthcare industry bears a substantial burden due to cognitive issues [7, 8], highlighting the urgent need to identify early signs of diminished cognitive ability. While pharmacological treatments for cognitive decline are limited, lifestyle modifications and dietary interventions have proven highly effective in slowing down its progression [9]. Risk factors associated with cognitive impairment are being increasingly reported, emphasizing the significance of lifestyle and dietary factors associated with cognitive function [10–16].

Several dietary nutrition components from the diet have been shown to have either protective or detrimental effects on cognitive function [17–19]. Vitamin B1 (VB1) plays an impressive role in neuropathology [20–23]. VB1 has been reported to be associated with neurological disorders due to its contribution to the synthesis of acetylcholine [24,25]. VB1 deficiency can lead to serious brain disorders, including consciousness of thought [26]. A cross-sectional study found that blood vitamin B1 levels were positively associated with cognitive function in non-demented Chinese older adults [27]. Low plasma VB1 level is also associated with mild cognitive impairment in men with Parkinson's disease [28]. Moreover, VB1 intake was found to be positively associated with better cognitive function in a study of Korean adolescents and children [29]. However, findings from studies of the relationship between VB1 and cognition are not entirely consistent. A systematic analysis noted that there is insufficient evidence to support an association between higher VB1 intake and better cognitive function [30]. The controversy over the association between VB1 and cognitive function has been driving the advances in the field. A prospective study revealed no significant association between midlife VB1 intake and cognitive impairment in old age among Chinese living in Singapore [31]. Recently, a randomized controlled trial of 6-month vitamin B1 treatment in sepsis survivors found no improvement in cognitive function [32]. To date, no studies have explored the association between dietary vitamin B1 (VB1) intake and cognitive performance in a noninstitutionalized elderly population in the United States. The impact of dietary VB1 intake on cognitive function in a specific population has emerged as a prominent area of research. Therefore, we propose the hypothesis that vitamin B1 intake and cognitive function are strongly correlated in older adults.

Given the inconsistency of existing findings regarding the correlation between vitamin B1 and cognitive function, we decided to perform this analysis. Our study aimed to examine the association between VB1 intake and cognitive function in old adults using data from the National Health and Nutrition Examination Survey (NHANES) database.

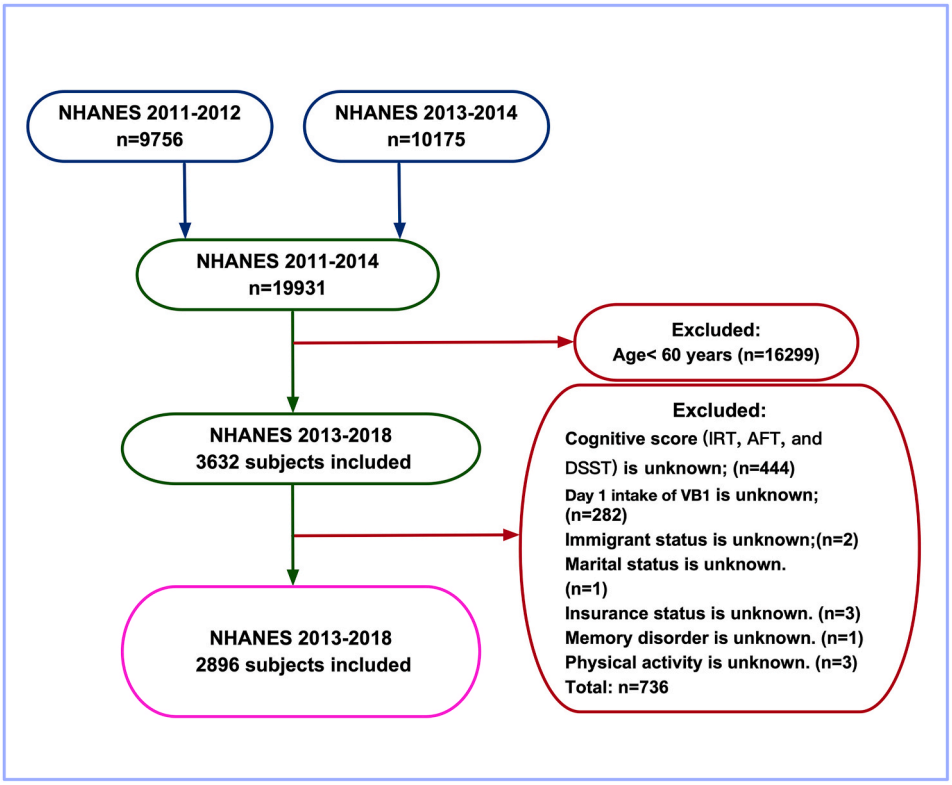

Fig. 1. Flowchart illustrating the study design and participants.

2. Methods

2.1. Data source and study population

The NHANES is a nationally representative sample of the ambulatory population in the United States, employing a complex multi-stage probability design. Participants underwent a face-to-face interview at their homes, while health measurements were conducted at the Mobile Examination Center (MEC). For this study, a total of 2896 respondents were included, representing the estimated population of 57.14 million older adults aged >60 years in the United States (Fig. 1). Prior to their participation, all participants provided written informed consent. Inclusion criteria: (1) age no less than 60 years (2) ability to independently complete the cognitive score test (3) at least one of the 24 h or 48 h dietary recalls was non-blank (4) successful completion of all NHANES tests. Exclusion criteria: (1) age less than 60 years (2) inability to independently complete the cognitive score test or cognitive scores are missing data (3) either 24 h or 48 h dietary recall data are missing (4) other covariate values are missing (Fig. 1).

2.2. Variables

To assess the cognitive abilities of older individuals, we utilized three tests: the immediate recall test (IRT/CERAD), the animal fluency test (AFT), and the digit symbol substitution test (DSST) [11]. Consistent with established practice in the literature, we used the lowest quartile (25th percentile) of test scores for the entire adult population aged 60+ as the cut-off point for the subpopulation [33]. The cut-off points identified based on the three cognitive scores were 15.625, 12.0, and 33.0, respectively. VB1 intake was treated as a continuous variable in our analysis. Post-quartile VB1 intake was subsequently considered a categorical variable. For the accuracy of our conclusions, we normalized the VB1 data and calculated the relevant results for 'Per 1 SD' (SD = 0.643 mg). Finally, we substitute the median of each quartile of VB1 for the quartile, and substitute it into the logistic regression model to calculate "*P* for trend".

The insurance status of participants was determined based on their responses to the question, "Are you covered by health insurance or some other kind of health care plan?" as derived from the questionnaire. Memory confusion was assessed during the question, "During the past 12 months, have you experienced confusion or memory loss that is happening more often or is getting worse?" Alcohol consumption was classified into four categories according to the rules set by the National Institute on Alcohol Abuse and Alcoholism (NIAAA): never, moderate (male, ≤2; female, ≤1), heavy (male, 3–4; female, 2–3), and heavy (male, ≥5; female, ≥4). Waist Circumference was categorized as normal (male, <94 cm; female, <80 cm), moderate (male, 94–102 cm; female, 80–88 cm), and high (male, ≥102 cm; female, ≥88 cm). Similarly, body mass index (BMI) was divided into three categories: normal (<25 kg/m^2), overweight (25–30 kg/m^2), and obesity (>30 kg/m^2). Physical activity levels were classified as sedentary, moderate, and vigorous. Missing data were not included in the logistic regression model. A weighted multivariate logistic regression was conducted to examine the association between VB1 intake and cognitive function, adjusted for variables such as age, gender, race, education level, poverty-income ratio (PIR), consumption, physical activity, and memory confusion.

2.3. Sensitivity analysis

Four sets of sensitivity analyses were performed. First, we analyzed whether the association would be valid if the data were in a different form (vitamin B1 quartiles). Second, we standardized the data by introducing Per 1 SD in units of one standard deviation to see if the association was stable. Third, whether the results changed with different statistical methods. We conducted subgroup analyses to explore the possibility that interaction effects existed. Finally, RCS curves were applied to present continuous associations between vitamin B1 intake and the risk of developing low cognitive performance adjusted for multiple covariates.

2.4. Statistical analysis

The analysis presented in this study involved a pooled sample of older Americans aged ≥60 years from two NHANES survey cycles. Comprehensive data on various important confounding factors, including age, gender, ethnicity, education, PIR, physical activity, and memory impairment, were included in the analysis. A total of 2896 individuals were included in this cross-sectional study. To assess the association between VB1 intake and cognitive function in older adults, three multivariable logistic regression models (Models 1, 2, and 3) were constructed. Model 1 is an unadjusted crude model. Model 2 was adjusted for age, gender, race, and educational level in demographic characteristics. Model 3 was adjusted for other confounders affecting cognitive function, including PIR, physical activity, and memory confusion. We constructed these three models based on demographic characteristics, participant health information, and the multivariable logistic regression results.

The results are reported as effect estimates in the form of odds ratios (OR) and corresponding 95% confidence intervals (CI). Additionally, forest plots were generated to enhance the visual presentation of the results. Dose-response curves were utilized to evaluate the non-linear association between Vitamin B1 intake and cognitive risk. We used restricted cubic spline curves (RCS) to investigate the dose-response relationship between dietary vitamin B1 intake and the risk of cognitive impairment. The principle of adjusting variables in the RCS model is consistent with the three logistic regression models. In detail, "*lrm*" function was employed to include the vitamin B1 variable as an RCS term and the model was identified based on the adjustment of the different variables. Finally, we used the "*ggplot*" function to display the RCS curves. All steps are based on the R language. *P* for non-linear values less than 0.05 indicates that a non-linear relationship holds.

3. Results

3.1. Population characteristics

A total of 2896 participants, with a mean age of 68 (95% Cl, 63–75) years, were included in this study. VB1 intake was categorized into four quartiles: Q1 (0.067–1.016 mg), Q2 (1.017–1.340 mg), Q3 (1.341–1.762 mg), and Q4 (1.763–7.517 mg). The majority of participants were aged between 60 and 69 years, comprising 56% of the study population. The proportion of participants in the age

Table 1
Characteristics of the study population.

Characteristic	Total N[a] = 2896	Q1 N = 724[b]	Q2 N = 724[b]	Q3 N = 724[b]	Q4 N = 724[b]	P[c] Value
Age (years)	68 (63, 75)	69 (64, 75)	67 (63, 76)	69 (64, 76)	67 (63, 74)	**0.003**
Age group						**0.036**
60 to 69	1544 (56%)	382 (54%)	395 (56%)	355 (51%)	412 (61%)	
70 to 79	861 (29%)	230 (31%)	193 (27%)	236 (33%)	202 (27%)	
80+	491 (15%)	112 (15%)	136 (17%)	133 (16%)	110 (12%)	
Gender						**<0.001**
Male	1423 (46%)	245 (28%)	301 (35%)	376 (46%)	501 (69%)	
Female	1473 (54%)	479 (72%)	423 (65%)	348 (54%)	223 (31%)	
Race						**0.002**
Hispanic	548 (8%)	151 (10%)	137 (8%)	129 (7%)	131 (6%)	
Non-Hispanic White	1387 (78%)	285 (71%)	339 (77%)	381 (81%)	382 (82%)	
Non-Hispanic Black	703 (9%)	238 (15%)	185 (9%)	147 (7%)	133 (6%)	
Non-Hispanic Asian	213 (4%)	38 (3%)	49 (3.5%)	58 (4%)	68 (4%)	
Others	45 (1%)	12 (1%)	14 (2.5%)	9 (1%)	10 (2%)	
Education level						**0.004**
<HS	769 (17%)	249 (23%)	199 (17%)	170 (17%)	151 (12%)	
HS diploma	666 (22%)	158 (22%)	171 (24%)	172 (21%)	165 (22%)	
College/associates	1459 (61%)	316 (55%)	354 (59%)	381 (61%)	408 (66%)	
Immigrant status						0.140
Born in US	2220 (89%)	556 (87%)	552 (89%)	552 (88%)	560 (90%)	
Immigrant	676 (11%)	168 (13%)	172 (11%)	172 (12%)	164 (10%)	
Marital status						**<0.001**
Never married	172 (4%)	47 (4%)	46 (4%)	43 (4%)	36 (5%)	
Married or living with partner	1657 (65%)	349 (55%)	409 (64%)	427 (66%)	472 (73%)	
Divorced, separated, or widowed	1067 (31%)	328 (41%)	269 (32%)	254 (30%)	216 (22%)	
PIR						**0.002**
<1	472 (9%)	153 (12%)	122 (11%)	96 (7%)	101 (7%)	
1 to 3	1181 (37%)	300 (40%)	318 (40%)	295 (39%)	268 (30%)	
>3	1022 (48%)	203 (41%)	234 (44%)	281 (48%)	304 (57%)	
Unknown	221 (6%)	68 (7%)	50 (5%)	52 (6%)	51 (6%)	
Insurance						0.500
No	235 (5%)	63 (6%)	61 (5%)	60 (6%)	51 (5%)	
Yes	2661 (95%)	661 (94%)	663 (95%)	664 (94%)	673 (95%)	
Memory confusion						0.200
No	2473 (87%)	608 (84%)	621 (88%)	628 (89%)	616 (87%)	
Yes	423 (13%)	116 (16%)	103 (12%)	96 (11%)	108 (13%)	
Alochol consumption						**0.004**
Never	1083 (32%)	316 (40%)	295 (34%)	258 (31%)	214 (24%)	
Moderate	972 (41%)	207 (35%)	233 (39%)	261 (41%)	271 (47%)	
Heavy	314 (12%)	81 (12%)	80 (12%)	76 (13%)	77 (10%)	
Binge	495 (15%)	105 (11%)	111 (15%)	124 (15%)	155 (18%)	
Unknown	32 (0.7%)	15 (2%)	5 (0.4%)	5 (0.4%)	7 (1%)	
Physical activity						**0.006**
Sedentary	1245 (38%)	360 (45%)	307 (38%)	286 (35%)	292 (37%)	
Moderate	1134 (40%)	257 (35%)	309 (45%)	301 (42%)	267 (36%)	
Vigrous	517 (22%)	107 (20%)	108 (17%)	137 (23%)	165 (27%)	
BMI (kg/m^2)						0.800
Normal	761 (26%)	182 (25%)	179 (26%)	206 (28%)	194 (25%)	
Overweight	1059 (37%)	245 (37%)	266 (38%)	271 (37%)	277 (37%)	
Obesity	1076 (37%)	297 (39%)	279 (35%)	247 (35%)	253 (38%)	
Waist Circumference (cm)						0.300
Normal	405 (12%)	78 (9.3%)	96 (12%)	101 (12%)	130 (15%)	
Moderate	529 (17%)	119 (17%)	123 (15%)	139 (18%)	148 (17%)	
High	1962 (71%)	527 (74%)	505 (73%)	484 (71%)	446 (68%)	

IQR, interquartile range.
[a] Unweighted N.
[b] Median (IQR); n (unweighted) (%).
[c] Wilcoxon rank-sum test for complex survey samples; chi-squared test with Rao & Scott's second-order correction.

groups of 70–79 years and those aged ≥80 years was comparatively lower. Regarding gender distribution, there was a generally balanced trend, but the number of males was significantly lower than females in Q1, Q2, and Q3, while the opposite was observed in Q4. Regarding race, Non-Hispanic White participants were predominant, accounting for 78% of the study population, with the representation of other racial groups at <10%. As for educational attainment, the majority of participants (61%) had college or associate degrees, followed by those with a high school diploma (22%), and the lowest proportion had education below high school (17%). In the immigrant status panel, the vast majority of participants were Native Americans, constituting 89%, while immigrants accounted for only 11%. The highest proportion of the study population reported being married or living with a partner (65%), while a small proportion (4%) reported being unmarried. The remaining participants reported being divorced, separated, or widowed (31%).

Regarding PIR, a small proportion of the population was classified as poor (n = 472, 9%), while the majority belonged to the middle class or higher income brackets, reflecting the economic development of the United States. The prevalence of health insurance among all participants was comprehensive, with only 5% reporting no health insurance. Only 13% of participants had experienced severe memory confusion in the past year. In terms of alcohol consumption, one-third of the participants (32%) abstained from drinking, while a larger proportion engaged in moderate drinking (41%). Additionally, more than one-fifth of the participants reported excessive and heavy alcohol consumption. Regarding physical activity levels, approximately 38% of participants were sedentary and inactive, while a larger proportion engaged in moderate exercise (40%). About one in five participants had a habit of engaging in vigorous exercise. Regarding weight, approximately three-quarters of the population was classified as overweight or obese, with only 26% falling within the healthy BMI range. Furthermore, the distribution of waist circumference was particularly noteworthy, as only 12% and 17% had a normal and moderate waist circumference, respectively, and a striking 71% had a high waist circumference (Table 1).

3.2. The association between VB1 intake and cognitive function

According to the results of the multivariable analysis (Table 2), three models were constructed (Fig. 3). Models 2 and 3 incorporated some major covariates based on the crude model. Model 1 showed that the association between vitamin B1 intake and low cognitive performance in the elderly was statistically significant with the following odds ratios (ORs) and 95% confidence intervals (CIs): IRT, 0.76 (0.63, 0.92), P = 0.004; AFT, 0.56 (0.45, 0.72), P < 0.001; DSST, 0.57 (0.45, 0.71), P < 0.001 (Fig. 2). Model 2 adjusted for age, gender, and race based on Model 1, and this association remained statistically significant with the following odds ratios (ORs) and 95% confidence intervals (CIs): IRT, 0.70 (0.54, 0.91), p = 0.005; AFT, 0.63 (0.47, 0.84), p < 0.001; DSST, 0.63 (0.50, 0.80), p < 0.001 (Fig. 2). The final model (Model 3) still supported the association between cognitive function and vitamin B1 (IRT: 0.75

Table 2
Multivariable logistic regression analyses.

Characteristic	Weighted multivariable logistic regression					
	CERAD test		Animal Fluency test		Digit Symbol test	
	OR 95% CI	p-value	OR 95% CI	p-value	OR 95% CI	p-value
VB1 (mg)	0.72 (0.56, 0.92)	**0.004**	0.73 (0.57, 0.92)	**0.004**	0.70 (0.52, 0.94)	**0.010**
Age group		**<0.001**		**<0.001**		**<0.001**
60 to 69	reference					
70 to 79	2.57 (1.98, 3.35)		2.23 (1.62, 3.08)		2.23 (1.62, 3.08)	
80+	5.46 (3.41, 8.74)		4.20 (3.07, 5.74)		4.72 (2.69, 8.26)	
Gender		**<0.001**		0.150		**<0.001**
Male	reference					
Female	0.41 (0.29, 0.59)		0.81 (0.60, 1.10)		0.54 (0.39, 0.74)	
Race		**0.012**		**<0.001**		**<0.001**
Hispanic	reference					
Non-Hispanic White	0.53 (0.32, 0.87)		0.54 (0.39, 0.75)		0.23 (0.15, 0.34)	
Non-Hispanic Black	0.64 (0.47, 0.87)		1.77 (1.28, 2.46)		0.91 (0.70, 1.17)	
Non-Hispanic Asian	0.77 (0.44, 1.34)		2.72 (1.52, 4.87)		0.34 (0.21, 0.57)	
Others	0.60 (0.25, 1.44)		0.82 (0.29, 2.33)		0.06 (0.02, 0.14)	
Education level		**<0.001**		**<0.001**		**<0.001**
<HS	reference					
HS diploma	0.58 (0.41, 0.82)		0.93 (0.69, 1.26)		0.42 (0.31, 0.57)	
College/associates	0.40 (0.25, 0.64)		0.46 (0.34, 0.62)		0.23 (0.17, 0.32)	
PIR		**<0.001**		**0.022**		**<0.001**
<1	reference					
1 to 3	0.60 (0.44, 0.80)		0.74 (0.55, 1.01)		0.70 (0.52, 0.94)	
>3	0.40 (0.28, 0.59)		0.58 (0.39, 0.87)		0.30 (0.19, 0.48)	
Physical activity		0.073		**<0.001**		**<0.001**
Sedentary	reference					
Moderate	1.01 (0.80, 1.28)		0.56 (0.41, 0.75)		0.62 (0.46, 0.83)	
Vigrous	0.69 (0.48, 0.98)		0.50 (0.29, 0.85)		0.38 (0.22, 0.69)	
Memory confusion		**<0.001**		**0.023**		**<0.001**
No	reference					
Yes	1.80 (1.39, 2.32)		1.56 (1.03, 2.36)		1.90 (1.24, 2.93)	

OR, odd ratio; 95% CI, 95% confidence interval.

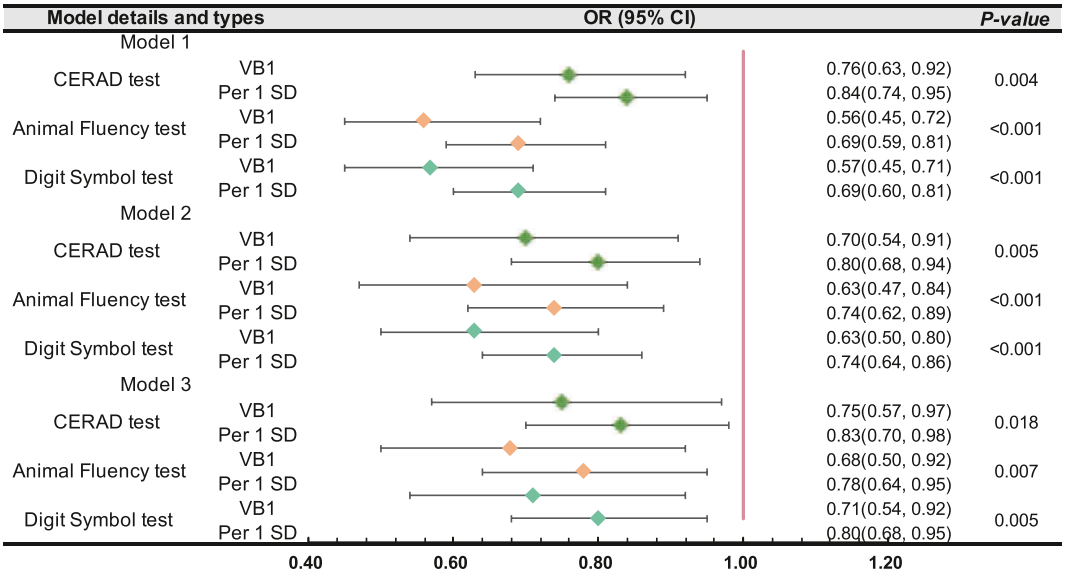

Fig. 2. Logistic regression models assessing the association between VB1 intake and cognitive function Model 1: unadjusted; Model 2: adjusted for age, gender, and race; Model 3: adjusted for age, gender, race, education level, PIR, physical activity, and memory confusion. OR, odd ratio; 95% CI, 95% confidence interval; CERAD, Consortium to Establish a Registry for Alzheimer's Disease; PIR, poverty income ratio.

[0.57–0.97], $P = 0.018$; AFT: 0.68 [0.50–0.92], $P = 0.007$; and DSST: 0.71 [0.54–0.92], $P = 0.005$) (Fig. 2). To further validate the association between cognition and VB1, VB1 was normalized to construct the model and the results remained consistent (Fig. 2).

To further investigate the association between VB1 intake and cognitive function in old adults, we categorized VB1 intake into four quartiles: Q1 (0.067–1.016 mg), Q2 (1.017–1.340 mg), Q3 (1.341–1.762 mg), and Q4 (1.763–7.517 mg). The lowest quartile group (Q1) served as the reference. Employing the same modeling approach, we found that the association between VB1 and cognition

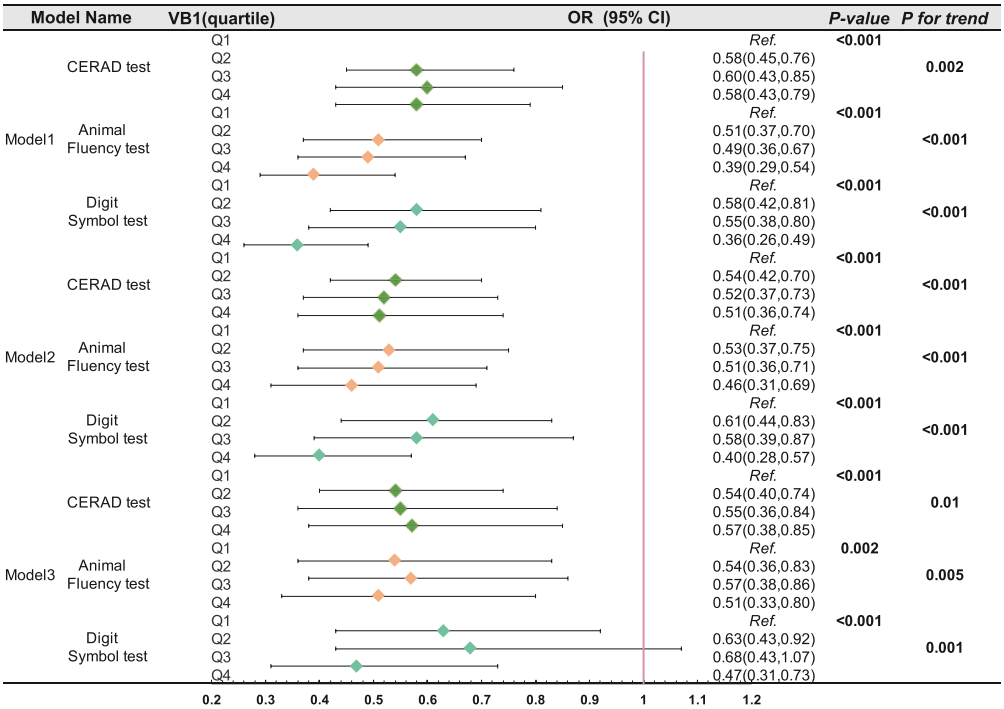

Fig. 3. Logistic regression model assessing the association between VB1 intake quartiles and cognitive function. Model 1: unadjusted; Model 2: adjusted for age, gender, and race; Model 3: adjusted for age, gender, race, education level, PIR, physical activity, and memory confusion. OR, odd ratio; 95% CI, 95% confidence interval; CERAD, Consortium to Establish a Registry for Alzheimer's Disease; PIR, poverty income ratio.

remained statistically significant after quartiles. In the final adjusted model, the association between VB1 intake and low cognitive performance was statistically significant with the following odds ratios (OR) and 95% confidence intervals (CI): IRT, Q1: Ref, Q2: 0.54 (0.40, 0.74), Q3: 0.55 (0.36, 0.84), Q4: 0.57 (0.38, 0.85), *p* for trend = 0.01; AFT, Q1: Ref, Q2: 0.54 (0.36, 0.83), Q3: 0.57 (0.38, 0.86), Q4: 0.51 (0.33, 0.80), *p* for trend = 0.005; DSST, Q1: Ref, Q2: 0.63 (0.43, 0.92), Q3: 0.68 (0.43, 1.07), Q4: 0.47 (0.31, 0.73), *p* for trend = 0.001 (Fig. 3).

To better elucidate the association between cognitive function and VB1 intake, weighted dose-response curves were constructed. The results suggested a non-linear association (P for non-linear <0.05) between the r cognitive function and VB1 intake (Fig. 4). Finally, stratified analyses and interaction effect judgments were performed (Table 3). The results showed no interaction effect between vitamin B2 and these confounders adjusted into the model (P > 0.05) (Table 3). Notably, subgroup analysis showed that the association between VB1 and cognitive function was statistically significant in men, whites, those with low education (<HS), and those without memory impairment (Table 3). These results similarly sustained that vitamin B1 intake is a protective factor against cognitive dysfunction.

4. Discussion

This cross-sectional study picked data from two waves of NHANES (2011–2014) to investigate the association between VB1 intake and cognitive function in older adults in the United States. Using a large sample from the United States sourced from the NHANES database, which provides a nationally representative sample, we identified a correlation between VB1 intake and cognitive function.

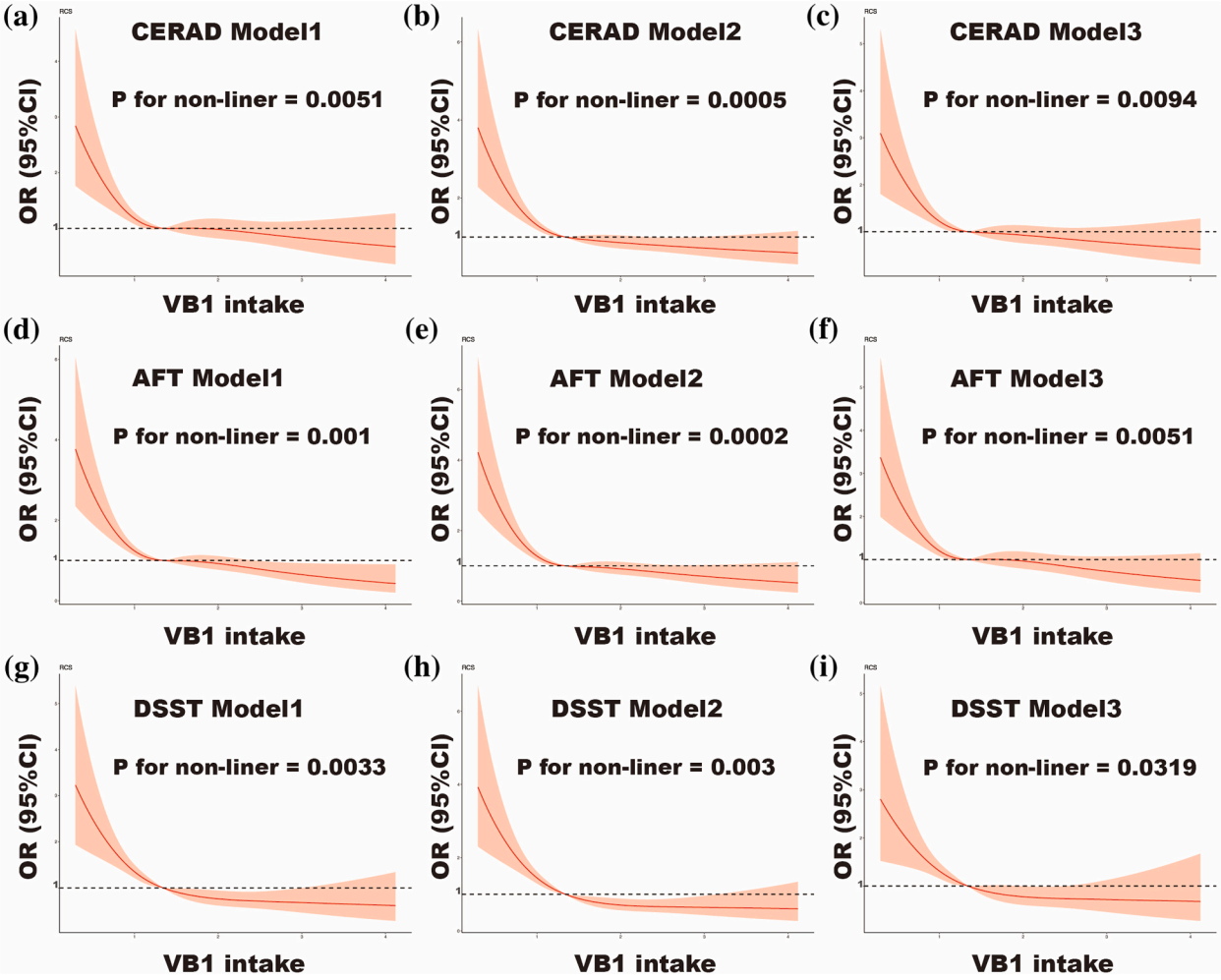

Fig. 4. Association between vitamin B1 intake and risk of cognitive impairment (a–c) Model 1 to 3 for vitamin B1 intake and CERAD; (d–f) Model 1 to 3 for vitamin B1 intake and AFT; (g–i) Model 1 to 3 for vitamin B1 intake and DSST; The red line and orange shading indicate predicted values and 95% confidence intervals, respectively. Model 1: Unadjusted model; Model 2: adjusted for age, gender, and race; Model 3: adjusted for age, gender, race, education level, PIR, physical activity, and memory confusion. OR, odd ratio; 95% CI, 95% confidence interval; PIR, poverty income ratio; CERAD, Immediate Recall Score (IRT); AFT, Animal Fluency Test; DSST, Digit Symbol Substitution Test.

Table 3
Stratified analysis and variable interaction with vitamin B1 (Model 3).

Stratified associations		Vitamin B1 (mg)					
		IRT OR (95%Cl)	*P* for interaction	AFT OR (95%Cl)	*P* for interaction	DSST OR (95%Cl)	*P* for interaction
Age (years)	**60 to 69**	0.67 (0.43,1.04)	0.736	0.72 (0.46,1.13)	0.350	0.80 (0.53,1.21)	0.824
	70 to 79	0.86 (0.62,1.21)		0.73 (0.50,1.08)		0.69 (0.46,1.06)	
	80+	0.71 (0.46,1.09)		**0.48 (0.29,0.81)**		0.63 (0.39,1.03)	
Gender	**Male**	**0.69 (0.52,0.93)**	0.562	**0.64 (0.45,0.90)**	0.739	**0.72 (0.53,0.99)**	0.974
	Female	0.81 (0.55,1.20)		0.72 (0.49,1.07)		0.69 (0.45,1.06)	
Race	**Hispanic**	0.96 (0.68,1.35)	0.663	0.82 (0.53,1.27)	0.927	1.03 (0.71,1.50)	0.256
	White	**0.73 (0.54,0.98)**		**0.65 (0.44,0.94)**		**0.65 (0.44,0.95)**	
	Black	**0.65 (0.42,0.99)**		0.74 (0.52,1.06)		**0.67 (0.45,0.98)**	
	Asian	0.86 (0.38,1.92)		0.74 (0.41,1.33)		1.01 (0.27,3.74)	
	Others	1.23 (0.10,14.8)		0.13 (0.01,1.52)		/	
Education level	**<HS**	**0.62 (0.43,0.90)**	0.230	**0.62 (0.44,0.88)**	0.705	**0.68 (0.48,0.96)**	0.085
	HS	0.84 (0.53,1.32)		0.73 (0.43,1.24)		1.07 (0.69,1.66)	
	College	0.77 (0.54,1.11)		**0.67 (0.45,0.99)**		**0.49 (0.30,0.80)**	
PIR	**<1**	0.97 (0.62,1.50)	0.260	0.80 (0.51,1.26)	0.057	0.70 (0.42,1.15)	0.053
	1 to 3	0.70 (0.47,1.03)		0.89 (0.64,1.24)		0.87 (0.61,1.24)	
	>3	0.67 (0.44,1.01)		**0.37 (0.19,0.69)**		**0.37 (0.22,0.65)**	
Memory confusion	**No**	**0.74 (0.56,0.96)**	0.656	**0.65 (0.48,0.88)**	0.626	**0.58 (0.43,0.78)**	0.068
	Yes	0.71 (0.44,1.15)		0.77 (0.46,1.30)		1.36 (0.80,2.31)	
Physical activity	**Sedentary**	0.76 (0.54,1.08)	0.926	**0.66 (0.47,0.93)**	0.682	**0.61 (0.43,0.88)**	0.213
	Moderate	0.73 (0.49,1.09)		0.77 (0.53,1.13)		0.78 (0.51,1.19)	
	Vigorous	0.73 (0.45,1.19)		0.61 (0.25,1.50)		1.14 (0.70,1.87)	

Note: *P* values were obtained by the likelihood ratio test.
Model 3: Adjusted for age group, gender, race, education level, PIR, memory confusion, alcohol consumption, and physical activity.

These findings indicate that enhancing dietary VB1 intake may contribute to improving cognitive performance in older adults.

As we know, increasing global aging leads to longer life expectancy for older populations. Aging-related cognitive impairment has a devastating impact on the quality of life of older individuals and imposes a heavy burden on the healthcare system [34]. In response to the situation, the center of public health efforts has shifted to promoting the cognitive health of older people [2]. Cognitive decline is a progressive process that encompasses various stages, including normal cognitive function, memory impairment, mild cognitive impairment, and dementia [35]. Prevention strategies during treatment are seen as key measures to influence the progression of cognitive impairment [36]. A growing body of research shows that improved dietary and nutritional conditions would protect neurodegenerative function in the elderly population [37–39]. The association between dietary nutrition and cognitive function is complex, but changing dietary nutrition is easy. Our clinical objective is to improve the condition of patients by controlling their diet, although it should be acknowledged that the underlying molecular mechanisms are of great importance and will require extensive research to fully understand.

Vitamins play a pivotal role in maintaining the human body and contributing to physiological and biochemical processes in the body. Vitamin B6 and B12 have been reported to contribute to DNA methylation, which is important for proper functioning [40]. Adequate dietary vitamin B9 and B12 intakes have been significantly associated with better cognitive function in older adults [41]. Higher vitamin D levels have also been associated with improved cognitive function and may serve as an indicator of delayed aging in individuals with longer lifespans [42]. In this study, we observed an association between VB1 intake and cognitive performance in old adults, even after adjusting for factors including age, gender, race, education level, PIR, physical activity, and memory confusion. Dose-response curves revealed that the risk of cognitive impairment decreases with higher intake of VB1 (Fig. 4). Our results unraveled to some extent the controversy over the association between VB1 and cognitive function.

Previous studies have highlighted the significant role of VB1 in neuropathology [43,44] emphasizing that VB1 deficiency can lead to severe brain disorders and cognitive impairments [45]. Although there are still some opposing results being derived from the study [30,31], population-specific correlation studies are still completely necessary. What distinguishes this study from previous ones is taking the older American population as the subject. Both continuous and categorical VB1 intake were consistently associated with cognitive function in older Americans. In the future, it will be interesting to explore in depth the underlying molecular mechanisms by which VB1 affects cognitive function in old age.

5. Strengths and limitations

This study has the significant advantage of reporting a correlation between VB1 intake and cognitive function. Additionally, we used NHANES, a comprehensive and rigorously designed database that collects data from scientifically sampled studies. The sample is weighted to ensure it represents the entire population of the United States, enhancing the generalizability and scientific validity of our findings. Additionally, we adjusted for several known potential confounding factors, such as age, gender, race, education, PIR, physical activity, and memory confusion. However, it is crucial to recognize that cognitive functioning is a complex and multidimensional construct. It is unlikely that a single test can fully capture all aspects of cognitive performance. While we used three representative cognitive test scores, they may not provide a complete and comprehensive assessment of the cognitive functioning of an individual.

Moreover, it is important to note that our study relies on cross-sectional analyses, which are limited to questionnaires, observations, and laboratory measurements. Establishing a causal relationship between VB1 intake and cognitive function would require longitudinal studies. Furthermore, there may be some older adults in the population who were unable to undergo all three cognitive tests, which may affect the representativeness of our sample about the overall older adult population of the United States.

6. Conclusions

Our findings indicate an association between VB1 intake and cognitive function in older Americans. The association between VB1 and cognitive function was statistically significant in males, whites, those with low education (<HS), and those without memory impairment.

Ethics approval and consent to participate

As a secondary data analysis of publicly available deidentified data, this study is not considered Human Subjects Research.

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Consent for publication

All authors approved the final version of the manuscript.

Data availability statement

The data we used is available on the official website of the National Health and Nutrition Examination Survey (NHANES). (https://www.cdc.gov/nchs/nhanes/index.htm; NHANES Data 2011–2014).

CRediT authorship contribution statement

Kangkang Ji: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Formal analysis, Data curation. **Minli Sun:** Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Project administration, Methodology. **Ye Hong:** Resources, Project administration, Methodology, Investigation, Data curation. **Li Li:** Validation, Software, Investigation. **Xin Wang:** Investigation, Formal analysis, Data curation. **Chaonian Li:** Methodology, Formal analysis, Data curation. **Shengkai Yang:** Methodology, Formal analysis. **Wenjuan Du:** Methodology, Investigation. **Kangjie Xu:** Formal analysis, Data curation. **Hai Zhou:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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